ORIGINAL PAPER

COGNITIVE FUNCTIONING AND MYOFASCIAL PAIN IN TEMPOROMANDIBULAR DISORDERS

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ABSTRACT

Introduction: Physical examination of patients suffering from temporomandibular disorders is increasingly accompanied by monitoring their psychological functioning. It includes basic diagnostics of the emotional and motivational sphere as well as, although rarely, the social sphere. Analysis of the pain profile changing under the influence of the therapeutic process and including the psychoneurophysiological aspect of the phenomenon suggests the need to extend the scope of assessment. Specific aspects of cognitive functioning covered by the research are mental activities that allow to create and modify knowledge about the environment and to control one's own reactions.

Objectives: The aim of this article is to describe in detail the cognitive functioning of patients suffering from temporomandibular disorders at various stages of prosthetic treatment, with particular emphasis on the experience of chronic pain.

Material and methods: The study included 45 patients, 23 were diagnosed with myofascial pain form of temporomandibular disorders and 22 diagnosed with temporomandibular disorders showing the same pathomechanism, but not reporting pain. Scheduled analysis included a number of inter-group comparisons based on the data obtained by using selected psychological tests and neuropsychological clinical trials.

Results: Statistically significant differences in cognitive functioning of patients suffering from pain due to temporomandibular disorders and those patients who did not experience pain, although were diagnosed with temporomandibular disorders, were observed.

Conclusions: It is important to take into account the psychological functioning of patients in a broader sense, including the neuropsychological mechanism of temporomandibular disorders myofascial pain.

Key words: myofascial pain, temporomandibular disorders, cognitive functions, psychostomatology.

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INTRODUCTION

ETYMOLOGY OF "MYOFASCIAL PAIN SYNDROME" TERM

Temporomandibular disorders have been variously defined over the years. Initially known as "Costen syndrome", concerns a group of symptoms including any disturbance of the jaw and ear due to loss of the back teeth in the jawbone and their too strong compression [1]. Later popularization of the name "pain and dysfunction syndrome of temporomandibular joint", "functional disorders of temporomandibular joint", "jaws' compression disorders" or "myoarthropathy of temporomandibular joint" was supposed to refer to alleged etiological factors connected with clinical symptoms [2-6]. However, due to the fact that the symptoms the above-mentioned names refer to occur not only in joints and muscles of the masticatory organ, some authors considered these terms too narrow, and further suggestions as for the names appeared such as "jaw and skull disorders" [7] or the (currently most popular though not non-universal) term "temporomandibular disorders" [8].

In the meantime the authors who wanted to underline that pain constitutes one of the most important symptoms of this clinical unit defined it as a "pain syndrome of masticatory organ dysfunctions", "myofascial pain syndrome" and "pain syndrome of temporomandibular joint dysfunctions" [3, 5, 9]. They noted that pain was the most essential factor that motivates patients to search for specialized help.

"Myofascial pain syndrome" (as understood in this article) is a wider term including movement organ disorders, in the etiology of which the priority is muscular component-like symptoms (as opposed to joint component) that raise the pain symptom to the level of the leading one. Myofascial pain syndrome diagnosed in this way does not constitute a separate unit within the International Classification of Diseases (ICD), belonging to category M79.1 (myalgia) [10].

MECHANISM OF MYOFASCIAL PAIN FORMATION

As a result of persistent temporomandibular disorders, a complex dysfunction of nerves and muscles, including movement disorders and sensory disorders within the central and peripheral nervous systems, developes [11]. In general it is easy to extract a number of changes and irregularities concerning interactions between opposite teeth, muscles responsible for articulation movements of the jaws and temporomandibular joint, on the basis of which chronic pain syndrome is shaped. If natural muscles functions' disorders, appearing as a consequence, continue, a number of local (biochemical) and global (structural) changes follow. The effect of fixed muscle injury, as well as developing further changes in muscle tissues that follow the injury, is persistent, permanent pain. If it lasts longer than 3 months, or does not disappear in spite of removing the reason of its occurrence, it is possible to diagnose it as chronic pain. Such pain affects the central nervous system and further enhances muscle and brain reactions.

Myofascial pain features local discomfort with sensitive areas experience associated with over-sensitive groups of muscle tissues called myofascial trigger points [12]. Knowledge about the mechanism of trigger points is incomplete, however most often covered with the combination of two leading theories: the theory of energy crisis and the motor theory of final junction [13-15, 17]. Simultaneously, it has been suggested that some end zones in muscle tissue can become sensitized by algogen – a substance that signals damage within the tissue. In the trigger points area temperature increases, which suggests higher metabolic demand and the necessity to reduce the blood flow to the problematic muscle tissue. It leads to tissue microvasculature disorders and decreased oxygen supply, which further disturbs the ability to gather energy (ATP) and metabolites [18] and eventually become the source of permanent, deep pain through the processes of stimulation and sensitizing of end zones. Trigger points can also evoke the central stimulation effects in peripheral zones when a group of interconnected interneurons is stimulated [19, 20]. Strong interaction of chemical and mechanical reflexes enhances sensitization of peripheral nerve ends and autonomic nerve fibers, resulting in reflective pain, increase in excitability of pain receptors as well as general hyperalgesia beyond the initial nociceptive area [21]. Acetylcholine leads to increased muscle tension which, eventually, evokes the energy crisis [22]. It probably originates from the interference during the integration mechanisms in the spinal cord, which constitutes a response to sensitization of nerve fibers connected with motor plates' (contact places of muscle tissues and motor neurons) incorrect functioning [23] or intrafusal fibers' (modified muscle fibers creating muscle spindles) irritation [15, 24].

As a consequence of the above-described mechanism there is a functional and structural reorganization of the central nervous system [25-27], comprising changes in the grey matter in the callosal gyrus, the orbital cavity and the forehead cortex, the insula, the dorsal part of the pontine, the thalamus, the dorsal and side part of the prefrontal cortex, the nucleus and the hippocampus. Patients suffering from chronic myofascial pain present atrophy of the grey matter in dorsal and abdominal prefrontal areas as well as in the front hippocampus, being regions participating in modulation of pain, processing emotions and behavioral self-regulation as well as imagining and evoking scenes, future, autobiographical memories and visual perception [28, 29]. These morphological as well as behavioral effects of long-term exposure to chronic pain are often close in their image to long-term effects of interference in the masticatory

process. Direct reasons are to be searched for in either lower activity of the parasympathetic nervous system or effects of increased level of corticosterone in blood plasma.

NEUROPSYCHOLOGICAL CONSEQUENCES OF MYOFASCIAL PAIN

Neuropsychology is a science that involves describing the connection between construction and functioning of central nervous system as well as behavior. The behavior is perceived with reference to few aspects: cognitive functioning (perception, memory, thinking, language skills such as reading and writing, constructive functions and praxis), executive functioning (that is being in close connection with action that is initiative and monitoring processes, and the ones finishing every action), global functioning (consisting of processes revealed in human behavior and characterized by great changeability, such as attention processes or psychomotor speed) as well as personal and emotional sphere [30]. In practice all the above, excluding emotional aspect, are investigated together under the common name of "cognitive functioning". Cognitive functions can be defined as mental activities enabling recognition of features and forms of the outer and inner environment, consolidating and combining them into a common and rather permanent representation. Therefore, it is an individual system of knowledge about the world enabling proper reaction to changing inner and outer situations or a change in conformity with own needs [31]. Cognitive functions can be divided in general into basic and complex ones. The first of them include perception, attention and memory, whereas the second ones include thinking (imagination), language function, cognitive control and executive functions [32].

The most often observed cognitive disorders (that is interference of mental processes) being the result of chronically experienced pain are decreased efficiency in the scope of attention possibilities, psychomotor speed and memory as well as solving problems, abstract thinking and cognitive effectiveness [33-37]. Information devoted to these issues also include research conducted on patients with muscle and skeleton system disorders. Research devoted to patients with fibromyalgia, rheumatoid patients arthritis, experiencing muscle and skeleton pain with different placement and chronic pain of back demonstrated lowered attention, operation memory and memory dysfunctions in the broad sense (considering semantic and episode memory) [38-42].

Apart from the above, neuropsychological profiles can be separated for people experiencing chronic pain typical for a specific dysfunction in which disorder of some cognitive functions turns into leading disorder in spite of the fact that they do not exclude presence of other cognitive disorders. For example, it is accepted that in the case of fibromyalgia memory disorders (mainly episode and semantic memory) are the leading ones, however, it must be noted that the deficiency refers to explicit memory only while implicit memory remains untouched [38, 43-46]. So far, however, the neuropsychological profile for experiencing myofascial pain in the course of temporomandibular disorders has not been fully described – it seems so far that the main research efforts have been focused on the isolating of emotional factors regulating the occurrence and the course of disorders.

OBJECTIVES

This article tries to empirically establish the profile of cognitive disorders for a clinical group experiencing myofascial pain in the course of temporomandibular disorders as compared to a group of people who do not experience pain despite this type of disorders.

MATERIAL AND METHODS

The study included 45 people aged 20 to 75 (M = 35.39; SD = 11.03). The treatment group consisted of 23 people aged 20 to 75 (M = 35.63; SD = 12.19), 14 women and 9 men. The control group consisted of 22 people aged 24-53 (M = 35.06; SD = 9.49), 13 women and 9 men. The subjects were recruited from the patients diagnosed with the painful form of muscle-related temporomandibular disorders, who entered the clinic with the purpose of diagnosis and specialist treatment for the first time. The exclusion criteria were the patients' will and the general diseases that prevent the planned test procedure. Financial compensation for participation in the study was not provided; however, the patients had the opportunity to attend five psychoeducational meetings with a psychologist aimed at increasing awareness of a psychogenic factor in temporomandibular disorders and better stress management by learning techniques for reducing the level of perceived psychophysical tension.

Table 1 shows the frequency distribution of drugs used in the treatment of the subjects from the treatment group. Nonsteroidal anti-inflammatory drugs were mainly used in the treatment. Only four subjects from the treatment group were not treated with these drugs.

The study formed part of a bigger research project and was conducted with the use of psychological questionnaires measuring the currently and/or previously experienced pain as well as the quality of life among patients with temporomandibular disorders, in addition to psychological tests of paper-and-pencil type and computer clinical trials, consisting in performing tasks that measure specific cognitive functions.

The test battery consisted of:

- Demographics – self-made tool, used for gathering basic sociodemographic data as well as some of the

TABLE 1. Frequency distribution: drugs used in the treatment of subjects from the treatment group

Anti-inflammatory steroid drugs	1
Anticonvulsants	6
Antimigraine drugs	2
Nonsteroidal anti-inflammatory drugs (NSAIDs)	29
Vitamins and supplements	5
Anti-inflammatory drugs, immunosuppressive drugs	1
Antiallergic drugs	1
Anti-gastric acid secretion agents	1
Anticoagulants	1
Dermatological drugs	1
Anti-infective drugs	1

variables controlled further in the study: duration of pain experience, previous treatment, pharmacological background (drugs used, doses, etc.).

- Visual Analogue Scale (VAS) – a straight 100 mm long line with a clearly marked beginning (no pain) and its end (unbearable pain). The aim of each examined person is to mark a point on the scale which corresponds to the level of severity of pain.
- Pain Evaluation Sheet (Szatanik) – this is a shortened version of the McGill-Melzack Pain Questionnaire. The original tool consists of 78 adjectives (descriptors) divided into 3 classes: sensory, affective and evaluative. Each examined person chooses descriptors which best describe what she currently experiences. The version of the tool used in this project is simplified, consisting of 43 words divided into 2 categories: sensory and emotional. Reliability (Cronbach's α) of this questionnaire is acceptable (0.6-0.81).
- Californian Verbal Learning Test (RVLT) – this test requires that an examinee tries to repeat a list of 16 words previously read to him. This procedure is repeated five times, then the researcher reads a different list of 15 words, and each person is asked to repeat it. Then the examinee is asked to try to repeat words from the first list.
- Attention and Perception Test (TUS – Test Uwagi i Spostrzegawczości) – each examinee is asked to mark (during three minutes) some symbols among different but similar ones (e.g. numbers '3 and 8' among others. Each person will be administered one of two equal versions of the task.
- Digit Span Task (DST, a subscale in the Wechsler Intelligence Scale) – a person is required to repeat 3-9 digits forward and then 2-9 digits backwards. This subscale measures working memory, attention and concentration.
- Color Trail Test (CTT) – this test consists of two parts, A and B. It requires immediate recognition of symbolic meaning of numbers and letters, as well as an ability to repeatedly eye-search the entire worksheet in order to find the next number or letter under time pressure.
- Verbal Fluency Test (VFT) – each person is supposed to generate words beginning with an indicated letter for a period of 1.5 minutes, and then to generate words belonging to a category indicated by the researcher for the next 1.5 minutes.
- Wisconsin Card Sorting Test (WCST) – computer version: a person is presented with 4 sample cards and then she must divide up to 128 cards by following a certain rule (color, number or shape). This is a tool frequently used for measuring some aspects of cognitive control.
- Go-No go clinical trial – a person is asked to react by pushing a button whenever a letter e.g. 'p' is presented on the screen and not to react if e.g. 'r' is presented that way. In the second part of the study the person should now react when 'r' presented and not react when 'p' is presented. This is a common method of measuring cognitive control.

The battery of tests was taken twice by each participant (for both the experimental and the control group) – before and after the treatment (in 3 months' time). The order in which the tools are listed corresponds to the order in which they were used.

STATISTICAL ANALYSIS

The analyses carried out include intergroup and intragroup comparisons. The treatment group and the control group were compared using the independent (unpaired) samples *t*-test. Intragroup comparisons concerning the treatment group were carried out using the dependent (paired) samples *t*-test. Analyses concerning comparison of the treatment group and the control group in terms of differences between the first and second measurements were performed using a repeated measures analysis of variance in the mixed-effects model, considering belonging to the treatment group or to control group as a between-subjects factor. This type of analysis was conducted for the results obtained from Go/No-go trial and for the results from WCST.

RESULTS

INTERGROUP COMPARISONS

INTENSITY OF PAIN

The mean value of the results on the VAS scale in the treatment group was 4.76 with a standard deviation of 2.66 and was higher than the mean value in the control group, which was 0 for all the subjects. Based on the value of the independent samples *t*-test, it was found that the obtained difference was statistically significant, $t(22) = 8.76$, $p < 0.001$.

AUDITORY VERBAL LEARNING

Table 2 shows the mean values of the results of the Auditory Verbal Learning Test obtained in the treatment and the control groups. Two-sided independent samples *t*-test was added to the summary. There were no statistically significant differences. However, it is worth noting that the mean values of the results obtained in the fourth trial and fifth trial were lower in the treatment group than in the control group (cf. Figure 1).

ATTENTION AND PERCEPTIVENESS

The analysis of the mean values of the results of the Attention and Perceptiveness Test obtained in the treatment and the control groups examined with the two-sided independent samples *t*-test showed no statistically significant effects (cf. Table 3).

IMMEDIATE AND WORKING MEMORY

Table 4 below shows the mean values of the results of the Digit Span Task obtained in the treatment and the control groups. Two-sided independent samples *t*-test was added to the summary.

In this case, the mean values of the results obtained in the treatment group were lower than the mean values obtained in the control group (cf. Figure 2).

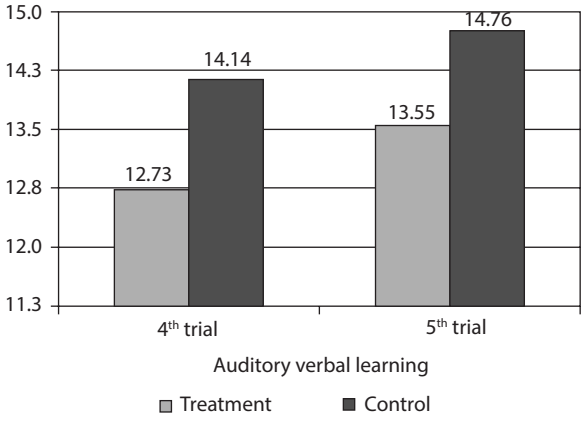

FIGURE 1. Mean values of the DST results obtained in the treatment and the control groups

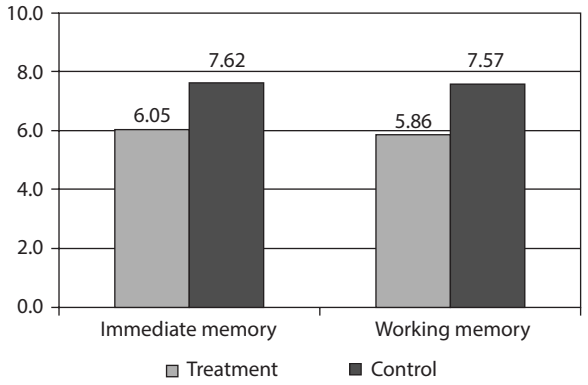

FIGURE 2. Mean values of the DST results obtained in the treatment and the control groups

TABLE 2. Mean values of results of the AVLT results obtained in the treatment and the control groups with the test of statistical significance

Variable	Group				*t*	df	*p*
	Treatment		Control				
	M	SD	M	SD			
1st trial	6.38	1.83	6.95	1.00	–1.27	30.64	0.214
2nd trial	9.48	2.38	10.27	1.39	–1.33	31.87	0.192
3rd trial	11.95	2.19	12.45	1.60	–0.86	42	0.392
4th trial	12.73	1.93	14.14	1.08	–2.98**	33.00	0.005
5th trial	13.55	1.71	14.76	0.44	–3.23**	23.85	0.004

*M – mean value, SD – standard deviation, t – test statistic, df – degrees of freedom, p – two-sided statistical significance; **p < 0.01*

TABLE 3. Mean values of the TUS results obtained in the treatment and the control groups with the test of statistical significance

Variable	Group				*t*	df	*p*
	Treatment		Control				
	M	SD	M	SD			
Number of responses	15.00	2.39	15.77	1.02	–1.39	28.41	0.174
Number of correct responses	8.64	5.46	9.91	2.65	–0.98	30.41	0.333

M – mean value, SD – standard deviation, t – test statistic, df – degrees of freedom, p – two-sided statistical significance

CONTINUITY OF ATTENTION AND ALTERNATING ATTENTION

The two-sided independent samples *t*-test did not show statistically significant differences between the mean values of the results of the Trail Making Test obtained in the treatment and the control groups (Table 5).

VERBAL FLUENCY

Table shows the mean values of the results of the Verbal Fluency Test obtained in the treatment and the control groups. Two-sided independent samples *t*-test was added to the summary (Table 6).

Statistically significant intergroup differences were observed for the results obtained in the lexical category 30 seconds and 60 seconds, as well as in the semantic category 30 seconds. As can be observed, the mean values obtained in the treatment group were lower than the mean values obtained in the control group (cf. Figure 3).

EXECUTIVE FUNCTIONS

Table 7 shows the mean values of the results of the Wisconsin Card Sorting Test obtained in the treatment and control groups in the 1st and 2nd measurements altogether. The test of statistical significance of within-subjects effects conducted in the analysis of variance was added to the summary.

The mean values of the number of trials, non-perseverative errors, trials to complete first category, failures to maintain set and conceptual level responses were

TABLE 4. Mean values of the DST results obtained in the treatment and control groups with the test of statistical significance

Variable	Group				*t*	df	*p*
	Treatment		Control				
	M	SD	M	SD			
Immediate memory	6.05	1.73	7.62	1.28	–3.31**	39	0.002
Working memory	5.86	2.06	7.57	0.68	–3.63**	24.27	0.001

*M – mean value, SD – standard deviation, t – test statistic, df – degrees of freedom, p – two-sided statistical significance; **p < 0.01*

TABLE 5. Mean values of the TMT results obtained in the treatment and control groups with the test of statistical significance

Variable	Group				*t*	df	*p*
	Treatment		Control				
	M	SD	M	SD			
Result part A	28.79	11.32	25.01	8.26	1.27	42	0.213
Result part B	39.00	23.71	34.39	17.75	0.72	42	0.473

*M – mean value, SD – standard deviation, t – test statistic, df – degrees of freedom, p – two-sided statistical significance; **p < 0.01, ***p < 0.001*

TABLE 6. Mean values of the VFT results obtained in the treatment and the control groups with the test of statistical significance

Verbal fluency	Group				*t*	df	*p*
	Treatment		Control				
	M	SD	M	SD			
Lexical category 30 s	12.88	5.64	17.82	4.22	–3.13**	37	0.003
Lexical category 60 s	6.35	3.04	9.82	3.36	–3.33**	37	0.002
Lexical category 90 s	5.24	2.22	6.77	2.62	–1.94	37	0.060
Semantic category 30 s	16.94	4.56	25.64	6.02	–4.95***	37	0.000
Semantic category 60 s	9.88	3.35	12.59	5.11	–1.89	37	0.066
Semantic category 90 s	6.24	3.36	7.95	2.63	–1.79	37	0.081

*M – mean value, SD – standard deviation, t – test statistic, df – degrees of freedom, p – two-sided statistical significance; **p < 0.01, ***p < 0.001*

higher in the treatment group, while the mean values of perseverative responses and perseverative errors were higher in the control group.

REACTION TIME

Similarly, no statistically significant differences between the mean values of the results of the Go/No-go Trial obtained in treatment and control groups in the 1st and 2nd measurements altogether were observed. Table 8 includes the test of statistical significance of between-subjects effects conducted in the analysis of variance, added to the summary.

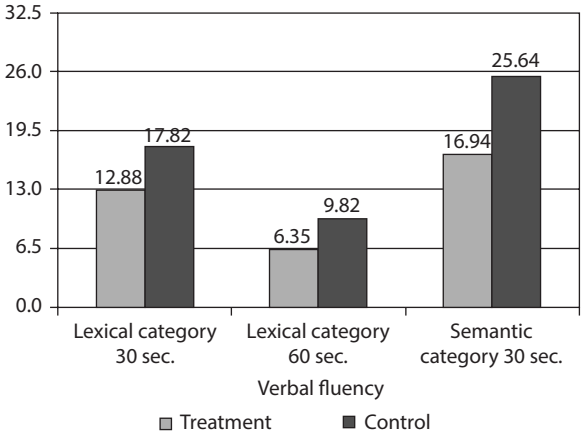

FIGURE 3. Mean values of the VFT results obtained in the treatment and the control groups

DISCUSSION

General cognitive functioning of people who experience dysfunctions of the masticatory organ should be defined as a high level, disregarding persistent chronic pain experienced. This is indirectly indicated by the analysis of researched people education, showing that only four people had basic education and all the others had higher education or were continuing education at the university. This is one of the main reasons why observing differences in cognitive functioning within this particular clinical group is so difficult. In other words, probably at least some of the diagnostic

TABLE 7. Mean values of the WCST results obtained in the treatment and the control groups in the 1st and 2nd measurements together with the test of statistical significance

Variable	Group				F	df	*p*
	Treatment		Control				
	M	SD	M	SD			
Categories achieved	2.91	1.14	2.90	1.72	0.01	1.40	0.983
Numer of trials	63.82	0.66	61.80	4.51	4.89*	1.40	0.038
Total number correct	45.45	8.63	40.90	12.13	2.29	1.40	0.138
Total errors	17.43	9.02	21.68	11.76	1.98	1.40	0.167
Perseverative responses	18.23	6.53	25.60	6.80	15.54***	1.40	0.001
Perseverative errors	7.98	5.79	15.85	8.62	13.69**	1.40	0.001
Non-perseverative errors	10.30	8.25	6.13	2.58	5.25*	1.40	0.027
Trials to complete first category	19.11	9.88	11.10	3.12	18.81***	1.40	0.001
Failure to maintain set	0.64	0.89	0.05	0.32	8.71**	1.40	0.005
Learning to learn	–5792.31	32267.36	0.14	2.86	0.22	1.14	0.647
Conceptual answers	39.84	11.64	31.53	13.49	4.88*	1.40	0.033

M – mean value, SD – standard deviation, F – test statistic, df – degrees of freedom, p – two-sided statistical significance

TABLE 8. Mean values of the Go/No-go Trial results obtained in the treatment and the control groups in the 1st and 2nd measurements together with the test of statistical significance

Variable	Group				F	df	*p*
	Treatment		Control				
	M	SD	M	SD			
Correct responses	310.55	6.41	308.79	4.27	1.36	1.41	0.250
Number of errors	8.91	6.36	9.36	3.74	0.10	1.41	0.755

M – mean value, SD – standard deviation, F – test statistic, df – degrees of freedom, p – two-sided statistical significance

tools applied in the study appeared to be too simple for the researched people, thus not too sensitive to potential cognitive deficiencies. Hence the lack of cognitive deficiencies found in the research group should not provide a conclusion concerning lack of certain dysfunctions in the population as a whole. What seems essential is the choice of proper diagnostic tools and special attention to subjective remarks applied by patients. It should be taken into consideration that in the case of people with a good level of cognitive functioning this will often be the information from the researched subjects that constitutes the source of diagnostic knowledge. Unfortunately, in a group of people with such good cognitive skills the smallest deviation from the standard will be subjectively perceived as even more severe.

Some differences were noted concerning the course of new information learning processes among people experiencing and not experiencing myofascial pain in the course of temporomandibular disorders. What is interesting, however, these differences could be observed during the fourth and fifth repetition of material by the researcher – then a distinct decline in the gaining of knowledge by people experiencing pain can be observed. Similarly, in initial stages of auditory and verbal learning it is comparable in the case of patients experiencing pain as well as those who do not experience it. This result may reflect some differences in attention functioning, modulating and controlling memory functioning, or executive functioning in the scope of ability to plan the learning process and/or to motivate to finish the task, which decrease with task duration. It is worth noting that during this part of the research patients experiencing pain often complained about the arduousness of the research process and declared an intention to give up the task if it lasted longer than five repetitions as planned. Such conclusions would be consistent with earlier research devoted to patients experiencing chronic pain [47, 48]. However, tiredness of the treatment group, appearing with time, cannot be ignored, as another, parallel explanation for the differences observed. Chronic pain proper for temporomandibular disorders makes it hard to be effective. These results are coherent with information concerning patients with fibromyalgia in whom an essential mediating role of effort put into the quality of cognitive tasks was observed, especially for memory tasks [49].

Analysis of results in the scope of continuity and shifting attention measured with the Point Matching Test did not prove any differences in functioning of the two groups observed in the study. The Point Matching Test is a tool in which people are asked to combine numbers with the use of straight lines in growing order as fast as possible, whereas on the second sheet they must be combined by turns with letters in alphabetical order. This tool, apart from efficient attentive functioning, requires efficient executive functions, especially planning ability and cognitive flexibility [50-53]. It seems, however, that these are in fact more complex cognitive functions, difficult to start in the case of a suggested task that other authors already paid attention to [53]. This result is similar to those obtained with the help of this tool (or similar tools) in the case of different kinds of chronic pain. Both during comparison to standard data [54] and comparison to healthy people [55] – no essential results have been obtained. What seems also significant is that this result is highly dependent on intellectual functioning, age or education [56, 57]. Simultaneously, research taking into account other kinds of measurements focusing on description of attentive and executive functioning of patients with temporomandibular disorders, allowed one to distinguish between people experiencing chronic pain and the others [58, 59].

Similarly, when it comes to other factors of attentive and perceptive functioning (the speed of perception, perception and attention unreliability as measured with the Attention and Perceptiveness Test) – the reseach did not confirm any differences between people experiencing myofascial pain and people not experiencing such pain. This result is different as compared to those achieved by e.g. patients with fibromyalgia [60]. As in the case of the previous tool, it can be assumed that the tool appeared to be too simple for this particular research group. Alternatively, it may be the case that the Attention and Perception Test as well as the Point Matching Test trials were too short. If extended by a few minutes, the procedure could possibly allow one to eventually observe some differences in attention and perception functioning of patients experiencing pain and those not presenting these kinds of symptoms. Some other results achieved in the same research may provide arguments for this second explanation.

At the same time, people experiencing pain achieved worse results for short term memory, as well as auditory and verbal operational memory, than people not feeling pain. This result is coherent with research devoted to chronic pain with various etiology [61-63]. Attention must be paid to the fact that performance in trials measuring short-term memory as well as operational memory requires efficient attention mechanisms. Therefore, it can be indirectly concluded that in the case of the researched group it turned out that mental processing of material was more difficult than carrying out operations on visual material. At the same time, lack of a visual stimulus leading through the task resulted in achieving worse quality of the task performed. It must be underlined at this point that people experiencing pain showed memory capacity (in the scope of direct capacity of auditory and verbal memory) matching Miller's number standards (7 ± 2 elements), which was reflected in both the digit matching test and the learning test.

Difficulty in the scope of cognitive functioning of people experiencing myofascial pain in temporomanidbular disorders, as compared to people who do

not experience this kind of pain, are also visible in word fluency trials. These are the tasks aiming at updating semantic knowledge resources (association aspect), the initiation process and activity control (including inhibiting unnecessary reactions), operational memory and attention, and cognitive flexibility enabling the initiation of various strategies (imagination, sound) (executive aspect) [64-66]. In the research differences in performance of tasks by people experiencing and not experiencing pain were visible in both cases during the first 30 seconds of the task – regardless of whether the task engaged lexical or semantic fluency. This result seems to confirm that both types of tasks are based on similar cognitive (semantic and executive) as well as neurophysiological mechanisms, including the role of the prefrontal cortex and anterior cingulate cortex of both hemispheres [69-74]. Simultaneously it suggests the decline in intentional attention (connected with conscious, intended, active orientation of cognitive functions to a given stimulus) in the case of people experiencing chronic pain in the course of temporomandibular disorders. In cognitive psychology there is a notion of 'cognitive warming up' which can be defined by mobilization, a state of increased readiness of cognitive processes to fulfill their function [75]. It seems that this notion can be applied to research results obtained, defining the research group as one representing essentially lower ability to start cognitive warming-up processes.

Lexical fluency in the 60th second of research shows difference between people experiencing pain and not experiencing pain, however there was no difference in semantic fluency. It can be therefore stated that myofascial pain seems to essentially disorganize word lexical fluency more than in the semantic one. This means that people experiencing this kind of pain have, in general, better ability to update words in a given semantic category than to update words starting with a given letter. It may result from the fact that semantic processing engages cognition more and influences the quality of the task performed. The assumption that stronger focusing on a task, resulting from the initiation of processing information on a deeper level, essentially decreases the overwhelming impact of the pain factor on cognitive functions, may be very hypothetical. This result can suggest predominance of the aspect of meaning in the information processing for people experiencing myofascial pain. As semantic fluency requires starting of recollection processes, sight and imagination processes, the result obtained can also suggest that people experiencing this kind of pain remain concentrated on these kinds of aspects of everyday experience. Quality analysis of words generated by patients with clear reduction of pain could turn out to be interesting, delivering interesting results about mechanisms of information processing in this group of patients [76].

In the Go/No-go clinical trial, constituting measurement of reaction speed as well as an ability to stop it, no vital differences were discovered, similarly to research devoted to fibromyalgia [77]. However, it must be noted that in research quoted in spite of differences found during research lowered activity was observed in those parts of the brain responsible for inhibiting reactions (frontal lower gyrus). It can be, therefore, assumed that although the suggested diagnostic procedure was not difficult enough to observe an explicit effect, in other, more cognitively engaging tasks such differences could appear.

The research also proved some differences in functioning of patients experiencing pain and those who do not experience it in the scope of executive functions. This result is even more interesting as only a few studies using the Wisconsin Card Sorting Test have proved so far any essential effects differentiating people experiencing chronic pain from the others [78, 79]. People experiencing pain featured a greater number of trials that were necessary to solve a problem task, longer process of initially looking for a concept and poorer ability to maintain the same attitude, that is completing the task without making a mistake (ie. resistence to frustration). These abilities surely refer to everyday existence of patients but also to a simple treatment process – among others, understanding own health situation and fulfilling the doctor's recommendations during the whole treatment process. What is important, however, is that not all the measured cognitive functions weakened in the case of patients experiencing pain. Better insight into the strategy of solving the task correctly is an example of executive functions that turned out to be more effective for pain feeling patients. It can be acknowledged as an effect of this not too numerous clinical trial or explained by noting that pain encourage people to look for its sense, meaning, aim.

CONCLUSIONS

Summing up, it must be observed that the neuro-cognitive profile of specific functions prone to the impact of myofascial pain in temporomandibular disorders seems to include executive functions, attention, operation memory, thus cognitive functions, with the essential role of the prefrontal cortex, especially its dorsal and side part. This brain area is important in higher forms of behavior, such as action planning and programming, performance control or its regulation. It seems, therefore, that it is the central nervous system that becomes one of the most encumbered by chronic myofascial pain in temporomandibular disorders. The obtained results seem to deliver a range of practical implications concerning the way patients are presented with information about diagnosis or treatment planning process. The results suggest that it is essential to lower the level of pain felt by patients fast, so that they can better and more actively partic-

ipate in the therapeutic process. Until considerable reduction of pain has been achieved, it is essential that the treating person pays attention to the way in which information is transferred to the patient and its context. Systematic work ought to be focused on increasing the level of resistence to both frustration and therapeutic failure, which seem essential in the context of the high rate of disorders recurrence.

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CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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